



S. Belomestnykh

Superconducting RF for storage rings, ERLs, and linac-based FELs:

- **Lecture 14** *Overview of remaining challenges*





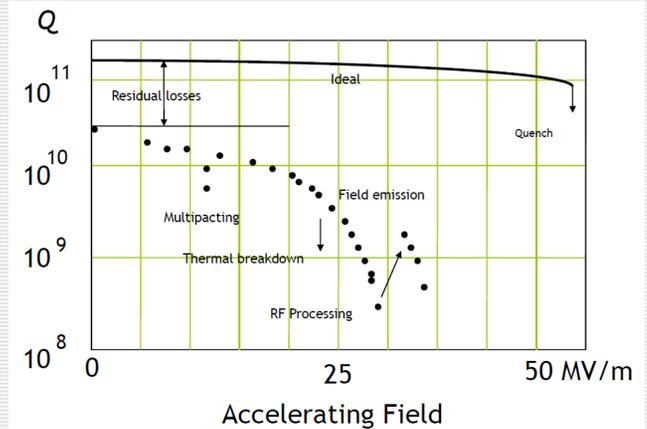
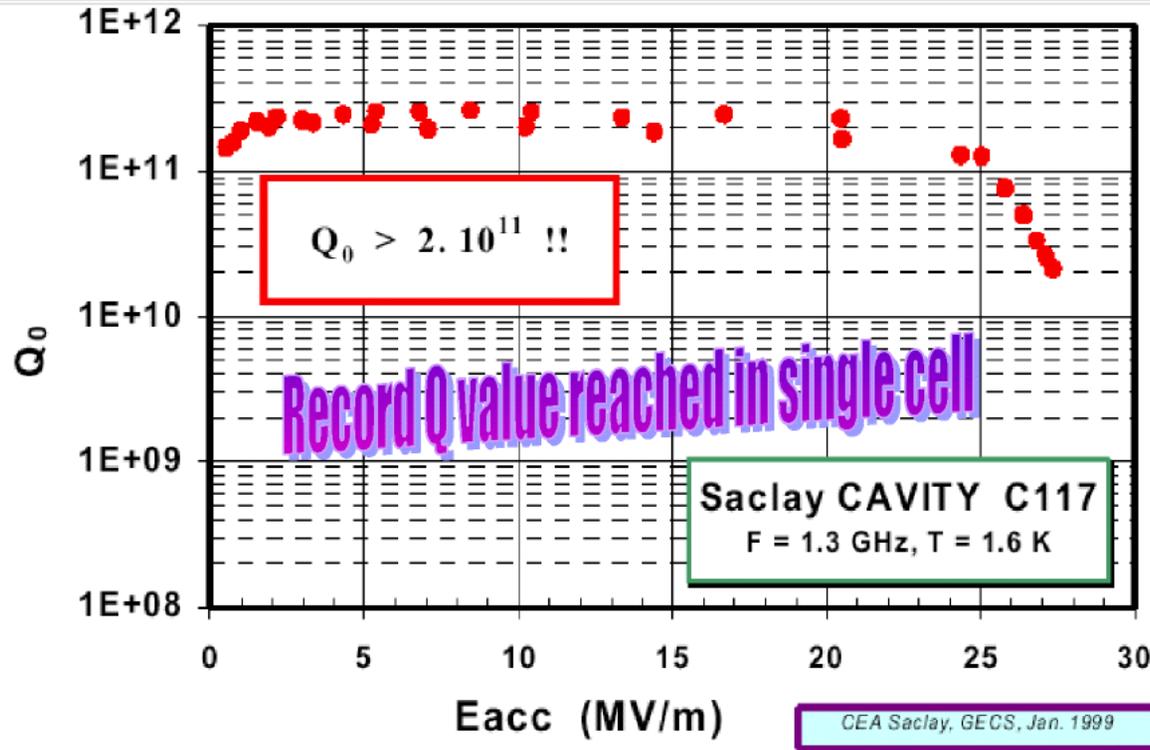
Short list of most important challenges (personal view)

- **Basic SRF studies:**
 - Nature of residual resistivity and how to consistently achieve low R_{res} in cavities.
 - Nature of Q-slopes.
 - Theory & experimental studies of weak Type II RF superconductors (Nb): what is the RF critical magnetic field?
 - Alternative materials to bulk Nb.
- **Cavity development:**
 - New & alternative cavity geometries;
 - New ways to fabricate cavities.
- **Other SRF technology challenges**
- **SRF guns**





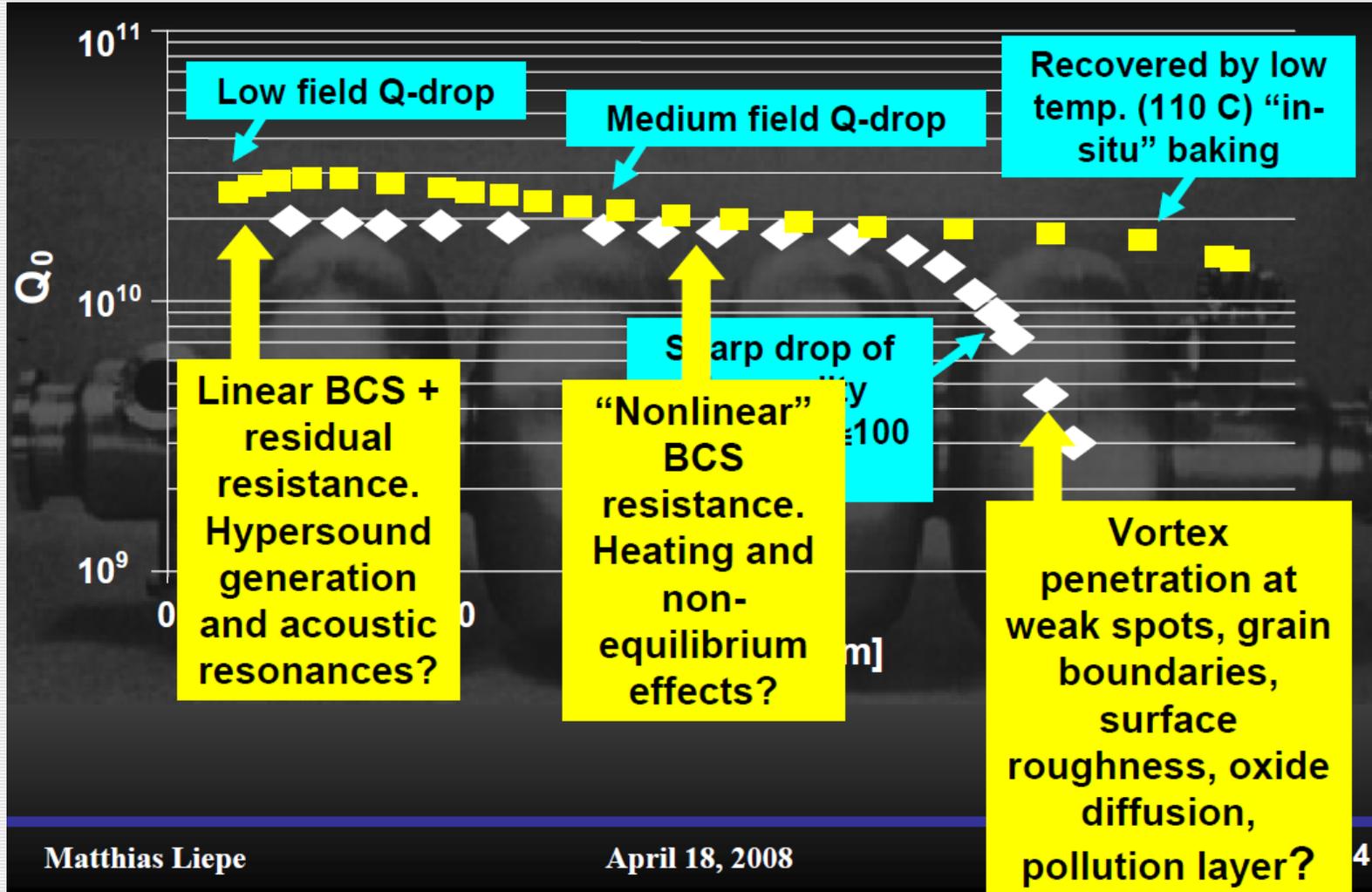
What causes R_{res} ?



- Record Q reached so far, 2×10^{11} corresponds to $R_s = 1.5$ nOhm and $R_{res} < 0.5$ nOhm!
- What is the physics behind the residual resistivity?
- Why cannot all cavities be like this?



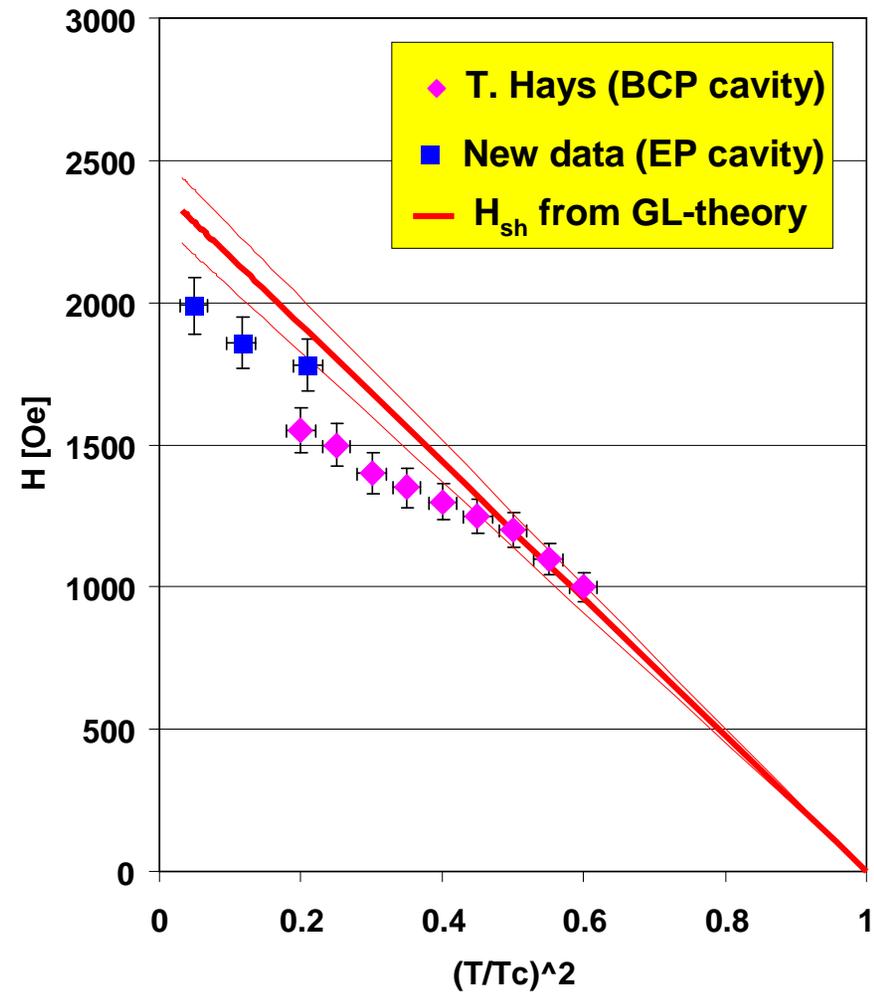
What is the nature of Q -slopes?





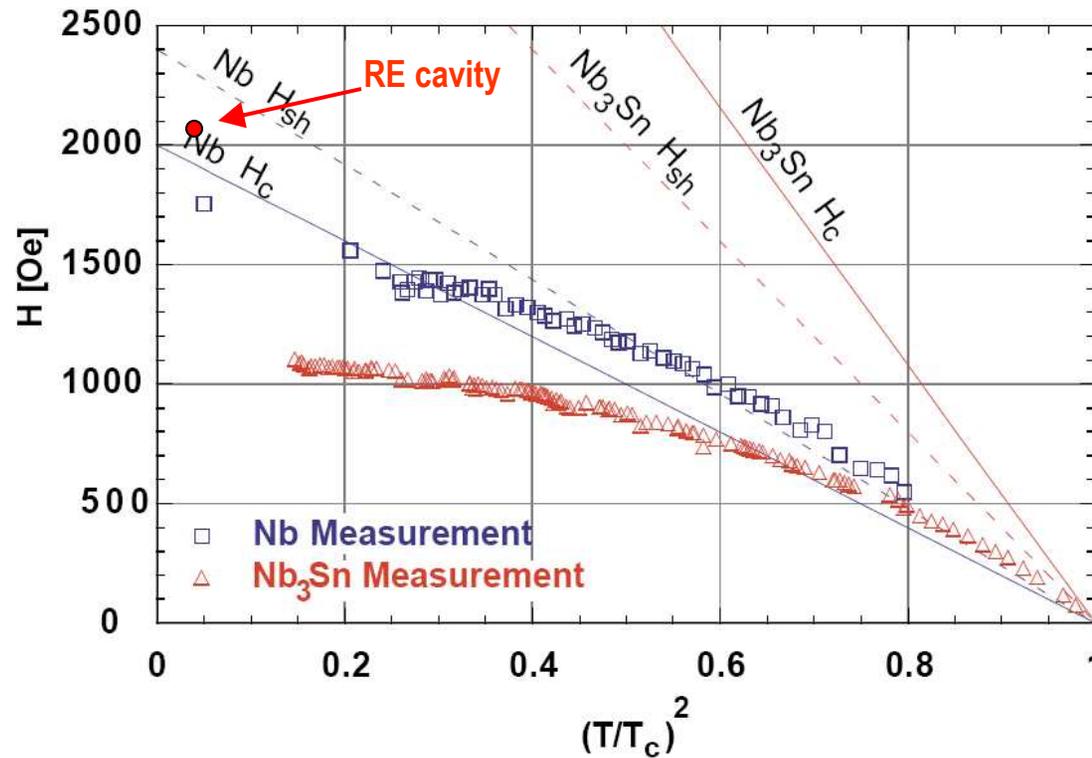
What is the critical RF magnetic field?

- Is it H_c , H_{sh} , H_{c3} or something else?
- We need advances in both theory and experiments to answer this question





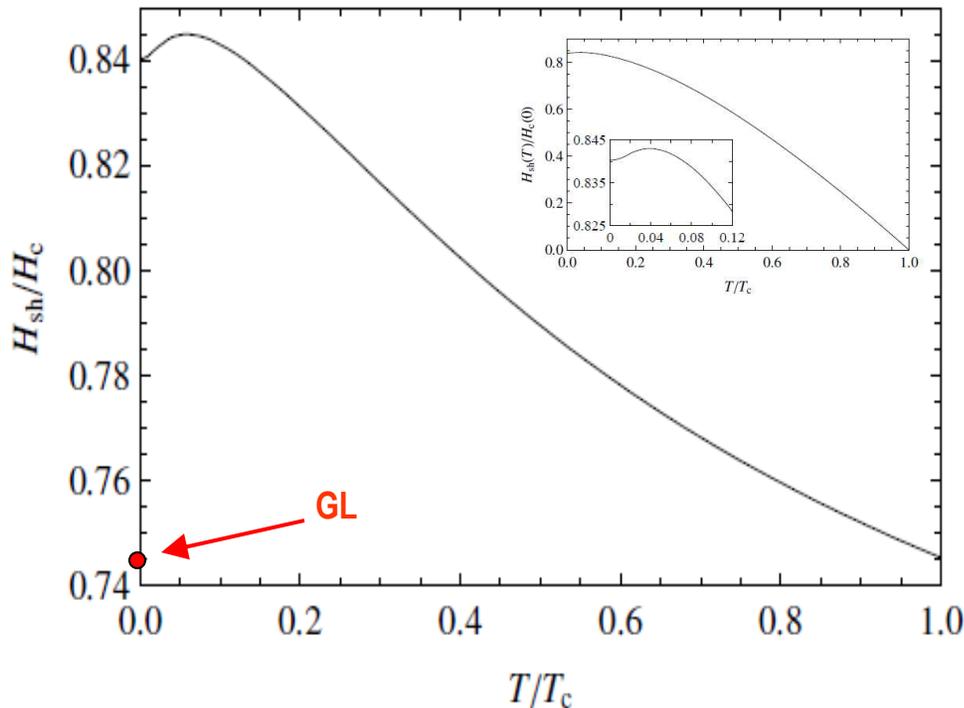
Can we make other materials to work better than Nb?



- Nb results are consistent with H_{sh}
- Nb₃Sn results fall short: Can we improve the quality of Nb₃Sn film and reach H_{sh} ?



Superheating field $H_{sh}(T)$ from the Eilenberger Equations
And large κ (so not applicable for Nb)
13% larger H_{sh} at low T than Ginzburg-Landau estimate !



H_{rf}-critical = H_{sh} ~
0.9 H_c

Which means

Theory gives hope for 100 – 200 MV/m !

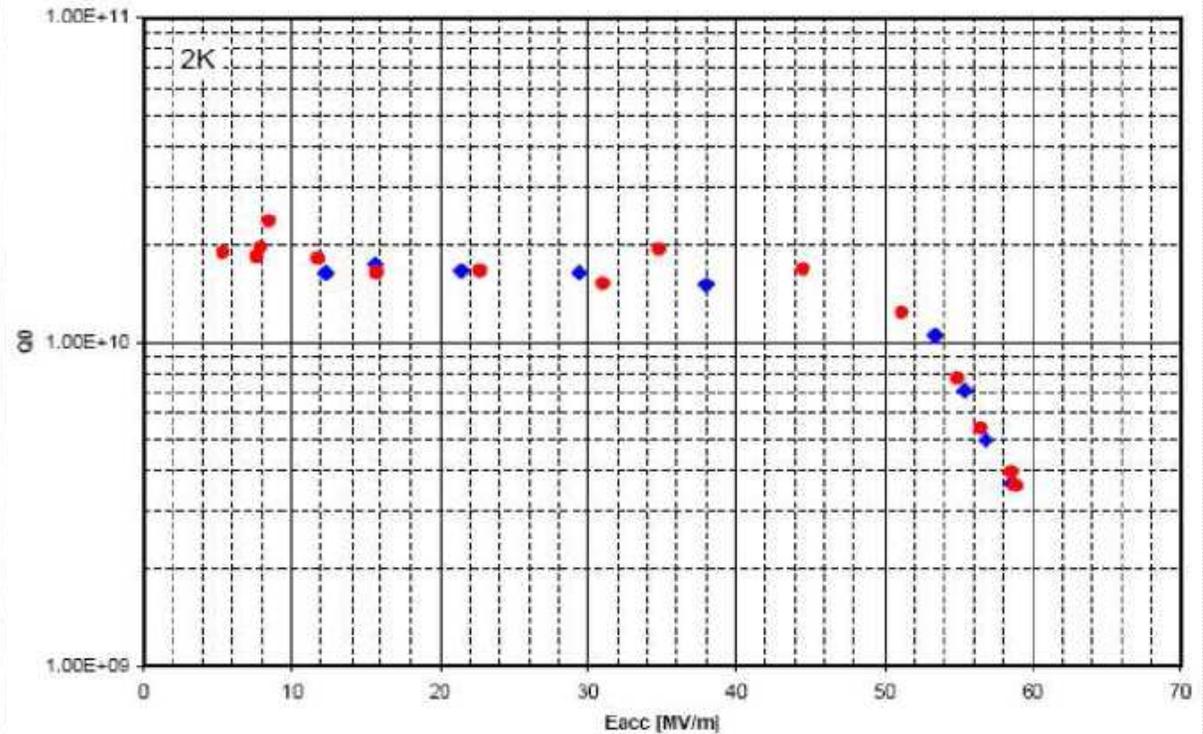
- Eilenberger (BCS) Theory predicts
- $E_{acc} \sim 120$ MV/m for perfect Nb₃Sn
- and 200 MV/m for perfect MgB₂ !!
- Strong motivation for materials and cavity push
- But be prepared for a long road to realization
- Can we do it?



Can we reach these gradients in multicell cavities? Are there better geometries?



Cornell 60 mm aperture re-entrant cavity LR1-3 March 14, 2007



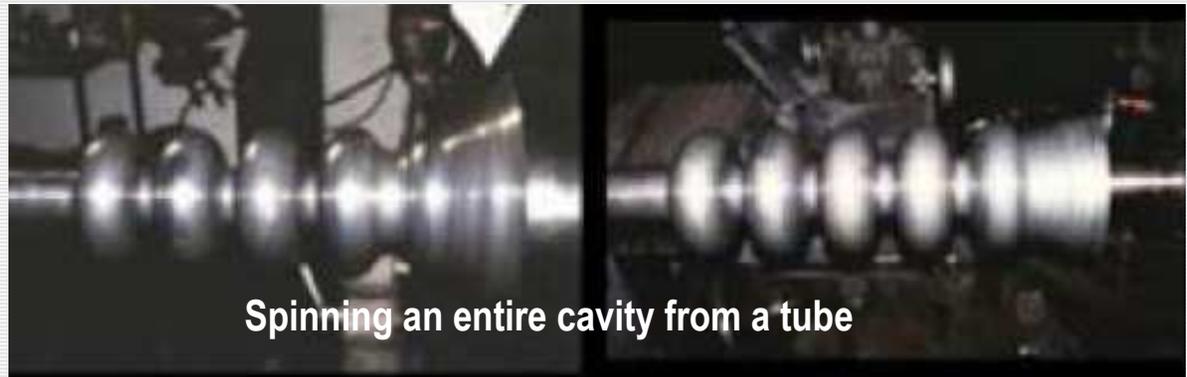
- $E_{acc} = 59 \text{ MV/m}$ corresponds to $E_{pk} = 125 \text{ MV/m}$ and $H_{pk} = 2065 \text{ Oe}$ at 2 K



Can we develop better (cheaper) fabrication techniques?



9-cell cavity welded from three 3-cell
hydroformed sections



Spinning an entire cavity from a tube

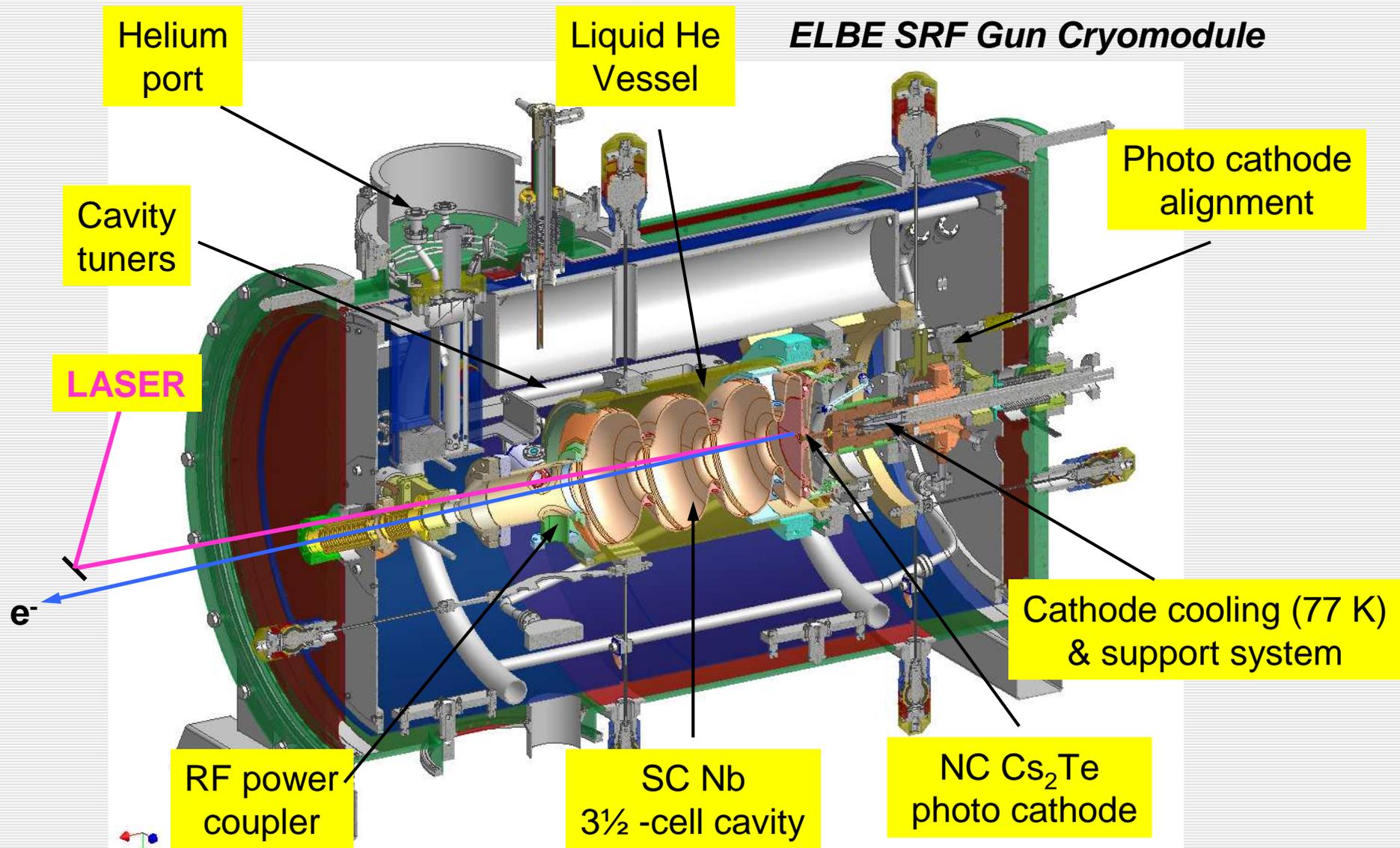
- Can we prove that this techniques produce cavities with good performance?
- Are they cheaper for mass-production?
- Are there other (better) techniques?



- ▶ Thin film technology & surface studies.
- ▶ Cavity treatment: new acid mixtures w/o HF?
- ▶ Input couplers for high average power.
- ▶ Alternative materials and coatings for RF windows.
- ▶ HOM couplers and new absorbing materials.

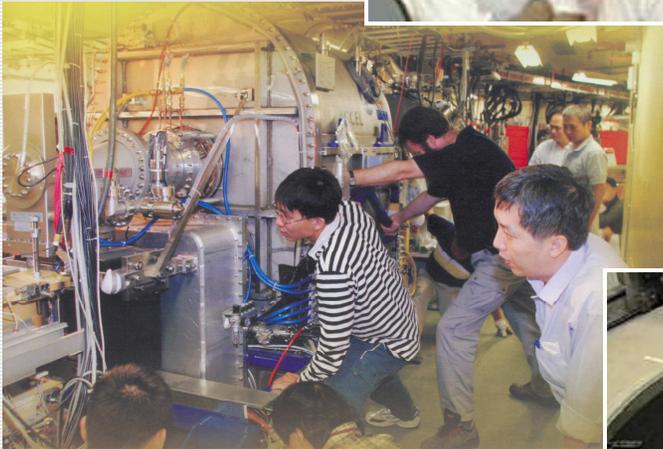
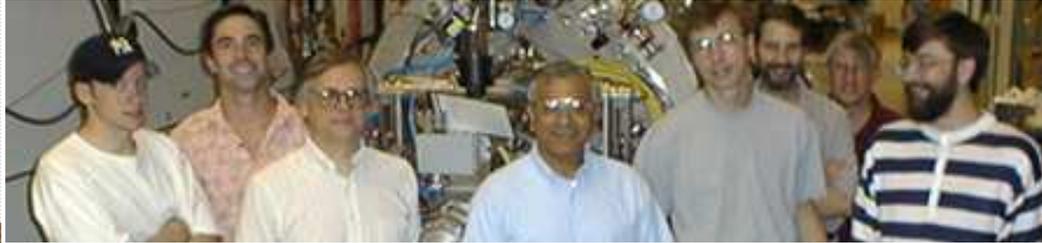


SRF guns





SRF: hard work and a lot of fun



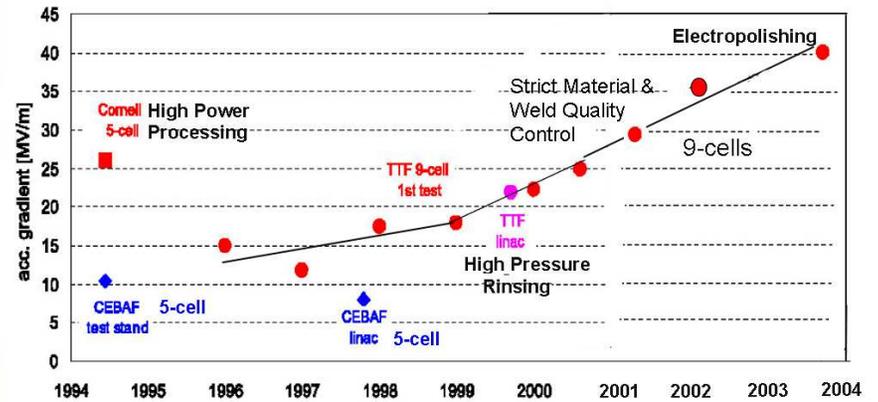


SRF around the world



Superconducting RF in Storage-Ring-Based Light Sources

SRF – A Robust Global Technology





Cornell University
Laboratory for Elementary-Particle Physics

SRF 2009 conference

held at Helmholtz-Zentrum
Berlin (formerly BESSY)
Sept 20th – 25th

Tutorials at FZ-Dresden
Sept 17th – 19th

srf2009.helmholtz-berlin.de

SRF09 Berlin · Dresden

14th INTERNATIONAL CONFERENCE ON

RF SUPERCONDUCTIVITY

DBB Forum, Berlin
September 20th–25th, 2009

Tutorials September 17th–19th, 2009
at FZ-Dresden

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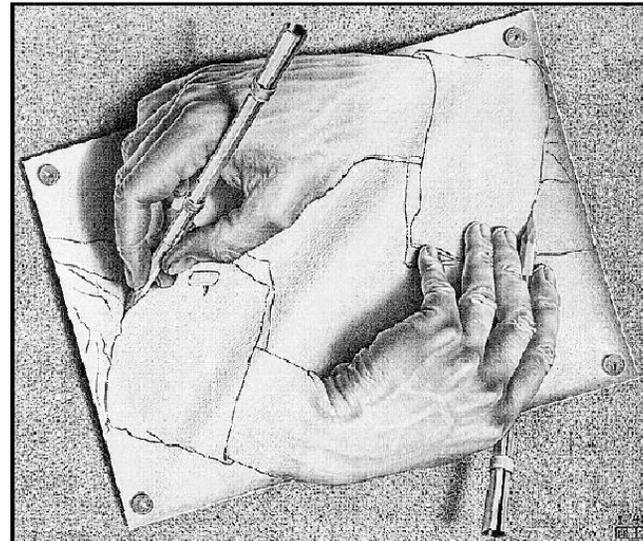
USPAS 2009, S. Belomesi



Concluding remarks

- ★ The field of RF superconductivity is very active.
- ★ The technology is mature and became the technology of choice for many accelerator types.
- ★ BUT: there are still many problems that need attention and careful investigation.
- ★ This will require better understanding of fundamentals and technological advances.
- ★ The design process will never be reduced to just a few simple rules or recipes.
- ★ There will always be ample opportunities for imagination, originality, and common sense.

Cavity Design is a Work of Art and Science
Calling for Imagination, Calculation, Symmetry.....



MC Escher



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See you next time at a conference or a
workshop related to RF superconductivity!

